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Cover Page Footnote

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Coping With the Subterranean Environment: A Thematic Content Analysis of the Narratives of Cave Explorers

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Abstract

In addition to various physical obstacles, the cave environment presents numerous psychological stressors that challenge human explorers. Sources of psychological stress include logistic issues (e.g., limitations to access, communication, and the availability of equipment), a lack of normal sensory stimuli, isolation and confinement, high performance demands, and social conflict associated with team coordination and requirements for cooperation. Thus, the success and safety of caving expeditions depend on the ability of explorers to effectively cope with highly stressful conditions and task demands. This was the first study to investigate coping within the context of caving and cave exploration. Utilizing scoring criteria from Suedfeld, Brcic, and Legkaia (2009), the narratives of 30 cave explorers were content analyzed for mentions of coping strategies across different expedition phases (pre-, during-, and post-expedition). Nationality and leadership status were also examined as potential moderators of coping. Narratives on the exploration of terrestrial, underwater, and terraqueous (i.e. sump-containing) caves were treated as unique conditions given marked differences in these forms of cave exploration. Consistent with previous research on groups performing in extreme and unusual environments, references to problem-focused coping strategies were, overall, more common than those to emotion-focused strategies. However, temporal analyses of coping across expedition phases showed that a more balanced coping orientation emerged post-expedition, with a significant difference in the use of problem-focused versus emotion-focused strategies no longer detectable. Significant effects of cave exploration type and nationality on the reference percentage of particular coping strategies were also detected. The relevance and implications of these findings are discussed, as well as limitations and directions for future research.

Keywords: caving, cave exploration, coping, diving, expedition, exploration, extreme environment, isolated and confined environment, performance, stress, thematic content analysis, qualitative research

Introduction

Since the beginning of history, humans have characteristically pushed the limits of their psychological endurance and technological capability in order to explore novel and challenging environments (Armitage et al., 2011; Huntford, 1979; Murray & Cox, 1989). Today, there are relatively few places on Earth that remain undiscovered and unexplored by humans. Of these uncharted places of the Earth, a prominent portion is constituted by the subterranean environment. In the last few decades, cave explorers have descended to depths of more than two kilometers below the surface of the Earth (Tabor, 2010), and have unveiled thousands of underwater passageways that combine to form complex networks (Kernagis, McKinlay, & Kincaid, 2008). Caves and cave exploration provide us with unique and invaluable opportunities for scientific discovery. New species, for example, are routinely being discovered in modern explorations around the globe (e.g., Andersen et al., 2016). Additionally, cave exploration has led to greater appreciation and understanding of the subterranean environment's importance in the broader ecosystem.

Wild caves, particularly in the context of exploration, represent what psychologists have described as extreme and unusual environments (EUEs; Suedfeld, 2012)—that is, environments which require specialized equipment or training for human survival, and that are characterized by conditions significantly different from typical, day-to-day human experience. Although the construct of EUEs is not necessarily synonymous with the related term "isolated and confined environments" (Suedfeld, 2012), isolation and confinement are aptly described as properties characterizing the cave environment.

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As EUEs, caves are inherently unpredictable and potentially hazardous places. Changes in precipitation aboveground can cause a rapid elevation in underground water levels, sometimes trapping or even drowning explorers (Pickup, 2010). Boulders or rock debris can unexpectedly fall from a cave's ceiling or, during the ascent or descent of vertical shafts, can accidentally be dislodged by fellow expedition members above. Protective head gear, artificial illumination, and navigational capability are essential for the successful exploration of terrestrial caves. Specialized clothing, climbing equipment, and climbing skills are also often necessary. With respect to underwater or sump-containing caves, technical diving equipment is almost always mandatory, especially in the case of the former. In some submerged sea caves, such as the Blue Holes of the Bahamas, currents can suddenly reverse due to particular hydrogeological properties, making the planning and timing of dives critical (Palmer & Farr, 1984; Whitaker & Smart, 1993). In general, claustrophobia, feelings of acute loneliness, cramped working conditions, social conflict, the death of friends/fellow party members during the mission, and the ever-present knowledge of potential danger are just some examples of the stressors experienced by cave explorers. In sum, caves are highly complex environments that present major logistic, technological, physical, and psychological challenges for those who explore them.

Effectively coping with these challenges is integral to the success and safety of caving expeditions. Acquiring knowledge about how cave explorers cope can be utilized to inform training protocols, the recruitment of personnel for expeditions, and other aspects of expedition planning. Additionally, this knowledge could potentially be generalized to other groups operating under similar extreme and unusual conditions. For example, the European Space Agency has recognized the cave environment as being an ideal analogue of an extraterrestrial exploration habitat (Bessone et al., 2013). Moreover, caves could serve as ideal places in which to establish long-term habitats on Mars, as they would provide protection from high levels of solar radiation present at the Martian surface (Boston et al., 2003).

To date, only a few studies have been published on the psychological aspects of cave exploration. Bishop, Santy, and Faulk (1998) presented a case study on the personality and group dynamics of cave explorers who participated in a major cave diving expedition in Mexico. However, difficulties encountered by the expedition, including the death of a party member and a breakdown in team structure, highly constrained the dataset available to the researchers. Pre-expedition responses to the NEO Personality Inventory suggested that participants could be roughly divided into one of two broad personality profiles. Half of the respondents showed personalities that were characterized by low Neuroticism, high Extraversion, high Openness, average Agreeableness, and mid-to-high Conscientiousness, while the other half presented personalities characterized by high levels of Neuroticism combined with low levels of Agreeableness and Conscientiousness. Research involving other groups performing in EUEs strongly suggests that the former personality profile would be more preferable to the latter in terms of performance (Bishop, 2004; Leon, Sandal, & Larsen, 2011), though this remains to be demonstrated in the context of cave exploration. With respect to group dynamics, it was reported by Bishop et al. (1998) that the breakdown of the expedition team was precipitated by a belief—shared by at least two of the cave divers involved with the expedition—that the expedition's leader placed excessive demands on the team's performance.

Oigarden's (2013) exploratory research on personality and dyadic adjustment in cave divers revealed several significant correlations. High levels of Neuroticism–Anxiety and Hostility–Aggression (as measured by the Zuckerman Kuhlman Personality Questionnaire) were associated with poorer dyadic adjustment. This finding is consistent with other research showing that individuals high in Neuroticism exhibit a maladaptive overuse of emotion-focused strategies when managing stressful situations and events (Bolger, 1990; DeLongis & Holtzman, 2005; O'Brien & DeLongis, 1996). The strongest correlation identified by Oigarden (2013) was between alexithymia and dyadic adjustment, with higher scores of alexithymia predicting poorer dyadic adjustment. Oigarden's (2013) results, however, were not exclusive to cave divers who were actively exploring, so their generalizability in this respect is limited.

Although no research to date has specifically studied coping in the context of cave exploration, or caving in general for that matter, it has been investigated in other groups who, either vocationally or recreationally, pursue activities in EUEs. Examples of such groups include astronauts/cosmonauts, mountaineers, search and recovery divers, and military personnel. The most prominent and consistent finding from research on groups entering EUEs is that problem-focused coping strategies are used much more frequently than emotion-focused coping strategies (Brcic, 2013; Leon, McNally, & Ben-Porath, 1989; Lester, 1980; Palinkas & Browner, 1995; Suedfeld, Brcic, & Legkaia, 2009). Suedfeld and colleagues (2009), for example, found that seeking social support (SSS), planful problem-solving (PPS), and endurance/obedience/effort (EOE) were the most commonly mentioned (in that order) coping strategies by astronauts and cosmonauts. The position of these strategies at the top of the astronaut/cosmonaut coping hierarchy was also maintained when coping was discretely examined before, during, and after spaceflight. This result was later replicated in a study that exclusively examined narrative coping data from retired cosmonauts (Suedfeld, Brcic, Johnson, & Gushin, 2015).

Mountaineering expeditions share many common elements with terrestrial and terraqueous caving expeditions. Importantly, both often require and/or involve the use of

technical climbing skills. Other similarities include a need to establish camps at different points along the journey, the difficulty of obtaining help or rescue in the event of an emergency, and the importance of weather conditions to expedition safety. There are studies that have shed light on the patterns of coping characteristic to mountaineers. In order to identify mental themes/strategies important for overcoming adversity during high-altitude climbing expeditions, Burke and Orlick (2003) interviewed ten elite mountaineers who had successfully summited Mount Everest. Participants noted mental strategies of maintaining focus, short-term goal setting, drawing on past experience, "feeling support" from others, believing in one's self, remaining mentally tough, and connecting with one's body as important for overcoming hardships encountered on the mountain (Burke & Orlick, 2003). Setting short-term goals and drawing on past experiences map onto the coping strategy of PPS in the Ways of Coping checklist (Folkman, Lazarus, Dunkel-Schetter, DeLongis, & Gruen, 1986). Similarly, remaining mentally tough is related to EOE, while receiving help from others is related to SSS. Brcic (2013) recently identified PPS as being the most frequently mentioned coping strategy by mountaineers, while EOE and SSS were found to be the second and third most frequently mentioned coping strategies, respectively.

In a recent study by Carey, Gallagher, and Greiner (2014), Irish search and recovery divers endorsed mission training, support from peers, and a sense of duty/purpose as the three most helpful coping factors in managing stress related to the recovery of human remains. These results were highly comparable to those obtained from an earlier study using the same measure in a sample of navy divers who participated in a major search and recovery operation in the wake of the explosion and crash of TWA Flight 800 off the coast of Long Island, New York (Leffler & Dembert, 1998). Unfortunately, search and recovery often becomes a task that many underwater cave explorers must also undertake. Although improved safety protocols, better equipment, and a stronger mandate for training have led to a significant decline in the frequency of cave diving-related fatalities over the years (Buzzacott, Zeigler, Denoble, & Vann, 2009), underwater caving and associated explorations remain characterized by a relatively high fatality-to-participant ratio.

To the best of our knowledge, the present study is the first to investigate the use of coping strategies in the context of cave exploration or caving. Based on previous research of EUEs cited above, we hypothesized that mentions of problem-focused coping strategies would, overall, be significantly more frequent than mentions of emotion-focused coping strategies. Furthermore, we expected that this difference would be most prominent for problems encountered during the expedition. In addition, PPS, EOE, and SSS were expected to occupy the top three positions of the cave explorer coping hierarchy. No other hypotheses were specified, as this study was predominantly exploratory in nature.

Methods

First-person, publicly available personal texts such as diaries, blogs, journals, media interviews, and books were analyzed. The dependent variable, coping strategies, was scored using thematic content analysis (TCA).

Thematic Content Analysis

TCA is an objective and systematic conversion of qualitative materials (e.g., diaries and interviews) into quantitative data allowing for standard statistical analysis (Carney, 1972). The impartial and consistent assessment of explicitly identified themes yields an objective system and unbiased and reliable results (Smith, 2000). This innovative approach facilitates the assessment at a distance of subjects who would otherwise be extremely difficult or impossible to study in a laboratory (e.g., high-profile political leaders, historical figures, terrorist leaders/organizations, astronauts, etc.). The scoring procedures were adapted from Suedfeld et al. (2009).

Scoring Procedures

Standard procedures regarding scorer training and inter-scorer reliability were implemented. All scorers attended a certification workshop for each independent variable. Scorers completed background reading on the theory, attended a workshop on scoring the specific variable, and practiced scoring selected passages according to established manuals. Trainees compared their scores to those of expert scorers, and discussed their answers with the leader and other students. The trainees completed a variable-specific test and achieved a total percent agreement of 85% or higher with expert scorers on test passages. In order to increase inter-scorer reliability, trainers were specifically taught not to infer beyond the written text.

To further ensure reliability, each archival source was scored by a main scorer and an independent reliability scorer. The main scorer was responsible for 100% of the material, while the reliability scorer was responsible for, on average, 25% of randomly selected passages. The two scorers needed to achieve a total agreement of 85% or higher in order to continue scoring. Any discrepancies were resolved through discussion between the scorers.

Subjects and Data Sources

All data sources were publicly available texts obtained from bookstores, libraries, or the World Wide Web. A total of 37 different narratives (Table 1) from 30 cave explorers were included in the analysis. The number of data sources

Table 1.
Data sources ($N = 37$).

Source Type	N
Memoirs	14
Expedition Reports	8
Interviews/Audio Transcripts	6
Autobiographies	4
Blogs	3
News Columns	1
Forum Posts	1

is unequal to the sample size because some subjects included narratives compiled from multiple sources, while some materials served as a data sources for multiple subjects. Given their voluminous nature, autobiographies and memoirs constituting entire books were only scored in part. The content from these materials to be included in the analysis was, by and large, selected in a random fashion. Some discretion had to be used in the case of multi-author works where the narrative content of a single subject represented only a small portion of the book. Five of these books had been translated from French into English. The textual materials span a relatively large time period, with the publication dates ranging from 1940 to 2013. Inclusion criteria for subject narratives required that the text predominantly focus on caving that involved an explicit objective to discover novel caves or cave passages. No specific exclusion criteria were applied.

Independent Variables

For the purposes of this study, we have identified three fundamental types, or categories, of cave exploration. These three categories of cave exploration correspond to distinct structural and hydrogeological cave environments, which may characterize a cave in its entirety or in part. Importantly, each of these three cave environments (underwater, terrestrial, and terraqueous) presents a unique set of challenges for explorers. Thus, the nature of exploration as it relates to these different cave environments was identified as an important independent variable. Subject narratives were scored with a focus on a single exploration category, namely that which represented the majority of content within his or her narrative(s).

Underwater cave exploration

This exploration category involves the exploration of caves or cave sections that are completely submerged under water. The exploration, surveying, and mapping of underwater caves involve an intimate dependence on human–machine interfaces, including life-support systems (e.g., an open- or closed-circuit underwater breathing apparatus), diver propulsion vehicles, dive computers, and other technical equipment. High performance demands require rigorous training and careful preparation. Low or zero visibility, guideline entanglement, nitrogen narcosis, and equipment failure/malfunction are just some examples of the problems encountered during the exploration of underwater caves that can have fatal consequences if not effectively coped with.

Terrestrial cave exploration

This category refers to the exploration of caves that are relatively dry or absent of water to the extent that explorers generally retain access to an air supply. Although terrestrial cave explorers do not need to be concerned about the hazards associated with cave diving (e.g., nitrogen narcosis, guideline entanglement, etc.), vertical shafts and pitches generally must be scaled using specialized climbing techniques and equipment.

Terraqueous cave exploration

Terraqueous cave exploration involves the exploration of caves comprised of terrestrial sections interspersed with completely flooded passages referred to as sumps or siphons. Explorers dive through sumps in an effort to discover additional "dry" passages beyond. Sumps can vary from being less than a meter to several kilometers in length. Ultimately, the full exploration of sump-containing caves demands that explorers use a combination of techniques, technology, and equipment necessary for exploring both terrestrial and underwater caves (Farr, 1991).

Nationality, leadership status, and expedition phase

In addition to the type of cave exploration (Underwater vs. Terrestrial vs. Terraqueous), other independent variables identified as being relevant to coping included *Nationality* (American vs. British vs. French) and expedition *Leadership Status* (Leaders vs. Non-Leaders). We initially intended to include sex as an independent variable, though a limited availability of female data ($n = 2$) precluded any meaningful assessment of this variable. Similar to Suedfeld et al. (2009), who compared the mention of coping strategies by astronauts before, during, and after spaceflight, the present study assessed potential differences in references to coping across the pre-, during-, and post-expedition phases. Passages of coping that explicitly referenced stressors associated with an upcoming expedition (e.g., dealing with problems such as personnel selection, supply acquisition, and finding financial sponsorship) were coded as pre-expedition. Passages of coping in reference to problems/stressors encountered during active explorations were classified as during-expedition. Passages of coping were classified as post-expedition if they had explicitly referenced a problem resulting from or related to a previous expedition. Finally, if it was not clear if a particular passage of coping was referring to a previous or upcoming expedition (in the case of narratives describing multiple expeditions that occurred in sequence), or if it was otherwise unrelated to any expedition, the expedition phase was coded as being "ambiguous". An overview of subject distributions across the independent variables is presented in Table 2.

Dependent Variable

In the socio-psychological framework, coping is defined as a dynamic physiological and psychological process in response to perceived environmental stress (Lazarus & Folkman, 1984; Pearlin & Schooler, 1978). More specifically, it is a process of "constantly changing cognitive and behavioral efforts to manage specific external and/or internal demands that are appraised as taxing or exceeding the resources of the person" (Lazarus & Folkman, 1984, p. 141). Coping functions to facilitate physiological homeostasis and reduce negative affect (Lazarus & Folkman, 1984; Suedfeld et al., 2009).

Coping strategies can be divided into two types: problem-focused coping and emotion-focused coping (Lazarus & Folkman, 1984). Problem-focused or task-oriented coping emerges when individuals perceive that their actions can and will change the situation. Most problem-focused strategies are oriented toward modifying the external environment. Examples include creating detailed plans to solve a problem or seeking help from others. Emotion-focused coping is more likely to occur if there has been an appraisal that nothing can be done to modify the environmental conditions. In this case, the individual may reframe the problem, reinterpret it, selectively pay attention to certain aspects of the problem, or deny the problem's existence.

The success of a coping mechanism depends on the situation. Problem-focused mechanisms are optimal for dealing with the stress at hand; however, if they fail they may leave the person at high physiological arousal for long periods of time (Holroyd & Lazarus, 1982). Emotion-focused strategies may be more adaptive when the situation is unchangeable and inescapable. Nevertheless, problem-focused mechanisms tend to lead to more satisfactory outcomes than emotion-focused ones, as the stressor is dealt with directly (Lazarus & Folkman, 1984).

Coping as a TCA Variable

A standard set of coping mechanisms (Table 3) was adapted from Folkman et al. (1986). The Ways of Coping checklist is one of the most widely used and validated measures (Folkman & Moskowitz, 2004); hence, the current measure was based on it. Supernatural Protection, Luck, and Endurance/Obedience/Effort were included as additional coping mechanisms, as these have been used in previous studies with Holocaust survivors and astronauts (Suedfeld, Krell, Wiebe, & Steel, 1997; Suedfeld et al.,

Table 2.
Distribution of subjects among grouping variables.

		Leadership status		Nationality			
Type of cave exploration (*n*)	**M/F[a]**	**Leader**	**Non-Leader**	**American**	**British**	**French**	**Other**
Underwater (8)	7/1	3	5	6	1	—	1
Terrestrial (16)	15/1	9	7	5	4	7	—
Terraqueous (6)	6/0	2	4	—	6	—	—
Overall, $N = 30$	28/2	14	16	11	11	7	1

[a] Male/female.

Table 3.
Coping strategies and their definitions.

Problem-oriented		
1	Planful Problem-Solving	Deliberate (rational, cognitively oriented) effort to change or escape the situation
2	Confrontation	Effort to resolve the situation through assertive or aggressive interaction with another person
3	Seeking Social Support	Effort to obtain sympathy, help, information, or emotional support from another person or persons
4	Escape/Avoidance	Efforts to escape or avoid the problem physically
5	Endurance/Obedience/Effort	Trying to persevere, meet demands
Emotion-oriented		
6	Distancing	Effort to detach oneself emotionally from the situation
7	Self-Control	Effort to regulate one's own feelings or actions
8	Accepting Responsibility	Acknowledging that one has a role in the problem
9	Positive Reappraisal	Effort to see a positive meaning in the situation
10	Compartmentalization	Encapsulating the problem psychologically so as to isolate it from other aspects of life
11	Denial	Ignoring or minimizing the seriousness of the problem, not believing in its reality
12	Supernatural Protection	Invocation of religious or superstitious practices; efforts to gain such protection (e.g., prayer, amulets)
13	Luck	Reliance on luck, chance

2009). See Table 3 for a list of the strategies and their definitions.

Results

Data were analyzed using IBM's statistical software package SPSS® Version 20.0. A series of ANOVAs were performed to assess potential differences in individual coping strategies based on the independent variables described above. In cases where data violated the homogeneity of variance assumption, results were reported based on Welch's *F*. Given its high power when comparing samples of unequal variances, the Games–Howell post-hoc testing procedure was applied when the homogeneity of variance assumption was not met (Field, 2009; Games & Howell, 1976). Hochberg's GT2 post-hoc test was used when the assumption was met. Importantly, both Games–Howell and Hochberg's GT2 post-hoc tests are robust when dealing with unequal samples sizes (Field, 2009), which was the case for most comparisons in the present study. Potential differences in references to coping strategies across expedition phases were tested using repeated-measures ANOVA. Where appropriate, significance for repeated measures analyses was reported based on the Greenhouse–Geisser statistic. Aggregate measures of problem-focused and emotion-focused coping were compared using a Student's *t*-test. All means and standard deviations are reported as percentages.

Overall Patterns of Coping

A hierarchy of overall references to coping strategies by cave explorers is displayed in Table 4. As expected, problem-focused coping strategies ($M = 71.29\%$, $SD = 12.63$) were mentioned significantly more often than emotion-focused coping strategies ($M = 28.71\%$, $SD = 12.63$; $t(29) = 9.24$, $p < 0.001$). As shown in Table 4, PPS was the most frequently mentioned coping strategy, followed by EOE ($M = 34.15\%$, $SD = 9.34$) and SSS ($M = 15.31\%$, $SD = 8.78$). Together, these three problem-focused strategies represented over 65% of all coping references in the dataset. The emotion-focused coping strategies Positive Reappraisal (PRA; $M = 8.19\%$, $SD = 5.19$) and Self-Control ($M = 6.45\%$, $SD = 5.43$) were the fourth and fifth most frequently mentioned strategies, respectively. This population rarely mentioned coping strategies of Supernatural Protection ($M = 0.83\%$, $SD = 1.52$), Denial ($M = 0.82\%$, $SD = 2.01$), Distancing ($M = 0.64\%$, $SD = 1.63$), and Compartmentalization ($M = 0.29\%$, $SD = 0.76$).

Table 4.
Hierarchy of overall references to coping ($N = 1084$).

Strategy	Orientation	Mean (%)	Standard Deviation
Planful Problem-Solving	Problem	34.15	13.07
Endurance/Obedience/Effort	Problem	15.78	9.34
Seeking Social Support	Problem	15.31	8.78
Positive Reappraisal	Emotion	8.19	5.91
Self-Control	Emotion	6.45	5.43
Luck	Emotion	5.87	5.26
Accepting Responsibility	Emotion	5.64	5.81
Confrontation	Problem	3.64	4.49
Escape/Avoidance	Problem	2.39	2.99
Supernatural Protection	Emotion	0.83	1.52
Denial	Emotion	0.82	2.01
Distancing	Emotion	0.64	1.63
Compartmentalization	Emotion	0.29	0.76
Problem-Focused Coping		71.29	12.63
Emotion-Focused Coping		28.71	12.63

While there was a significant predominance in references to problem-focused coping strategies over emotion-focused strategies at the pre-expedition ($t(25) = 9.23$, $p < 0.001$) and during-expedition phases ($t(29) = 10.81$, $p < 0.001$), this difference was not significant at post-expedition ($t(18) = -1.11$, $p = 0.28$).

Overall Differences Based on Cave Exploration Type, Nationality, and Leadership

The percent means and standard deviations of references to coping based on cave exploration type are presented in Table 5. A one-way ANOVA adjusted using Welch's test revealed a significant main effect of cave exploration type on the overall frequency of EOE mentions ($F(2, 15) = 6.44$, $p = 0.009$). As shown in Table 5, Games–Howell post-hoc comparisons revealed that overall references to EOE by terrestrial cave explorers ($M = 19.63$, $SD = 9.88$) were significantly more frequent than those by underwater cave explorers ($M = 8.16$, $SD = 6.04$; $p = 0.006$). A marginally significant trend toward higher referencing to EOE by sump-diving cave explorers compared to underwater cave explorers was also detected ($p = 0.06$). No significant differences were detected in overall references to coping strategies when assessing the effects of nationality or leadership status.

Changes Across Expedition Phases

The availability of coping data across all expedition phases was limited to 18 out of the 30 subject narratives. References to coping strategies that were determined to be ambiguous with respect to the expedition phase were excluded from these analyses. A repeated-measures ANOVA revealed a significant main effect of expedition phase on the proportion of references made to the aggregate measures of problem-focused coping and emotion-focused coping ($F(1, 24) = 16.51$, $p < 0.001$). The statistic is the same for both measures as they are perfectly correlated when expressed as percentages. Pairwise comparisons adjusted using Bonferroni correction showed that the proportion of

problem-focused coping references was significantly reduced at post-expedition ($M = 37.45\%$, $SD = 34.22$) as compared to pre-expedition ($M = 83.62\%$, $SD = 21.17$) and during-expedition ($M = 74.97\%$, $SD = 13.45$); $p = 0.001$ for both. Emotion-focused strategies were mentioned significantly more often post-expedition ($M = 62.55\%$, $SD = 34.22$), as compared to pre-expedition ($M = 16.38\%$, $SD = 21.17$) and during-expedition ($M = 25.03\%$, $SD = 13.45$); $p = 0.001$ for both. A graphical representation of the changes in general coping orientations across the expedition phases is shown in Figure 1.

Analyses of individual coping strategies using repeated-measures ANOVA detected a significant main effect of expedition phase on coping references of PPS ($F(2, 34) = 6.06$, $p = 0.01$), SSS ($F(1, 24) = 5.17$, $p = 0.02$), PRA ($F(1, 19) = 12.63$, $p = 0.002$), and Accepting Responsibility ($F(1, 24) = 9.31$, $p = 0.002$). As depicted in Figure 2, pairwise comparisons revealed a significant post-expedition decline in references to PPS when compared to references made during-expedition ($p < 0.001$). There was no significant difference between pre-expedition and during-expedition levels. Although a significant difference in the proportion of references to SSS was initially detected when comparing the pre-expedition and post-expedition phases, this result was not retained after adjusting for multiple comparisons ($p = 0.07$). With respect to emotion-focused strategies, PRA was mentioned significantly more often post-expedition than at either the pre-expedition

Table 5.
Differences in the proportions of overall coping references based on cave exploration type.

	Type of Cave Exploration					
	Underwater ($n = 8$)		Terrestrial ($n = 16$)		Sump ($n = 6$)	
Coping Strategy	***M* (%)**	***SD* (%)**	***M* (%)**	***SD* (%)**	***M* (%)**	***SD* (%)**
Planful Problem-Solving	35.59	12.42	30.69	11.36	41.45	16.79
Seeking Social Support	12.48	9.45	18.18	8.91	11.45	5.17
Endurance/Obedience/Effort*	8.16_a	6.04	19.63_a	9.88	15.68	4.75
Confrontation	4.29	5.25	4.23	4.51	1.18	2.90
Escape/Avoidance	3.25	3.08	2.07	3.09	2.12	2.87
Positive Reappraisal	8.51	6.86	8.40	5.45	7.20	6.78
Self-Control	10.26	7.06	4.89	4.17	5.50	4.10
Accepting Responsibility	8.79	6.57	3.43	3.33	7.33	8.20
Luck	3.83	3.29	6.99	5.69	5.58	6.09
Compartmentalization	0.25	0.71	0.15	0.60	0.72	1.13
Denial	1.81	2.84	0.00	0.00	1.70	2.76
Distancing	2.04	2.63	0.18	0.70	0.00	0.00
Supernatural Protection	0.78	1.50	1.17	1.75	0.00	0.00
Problem-Focused Coping	63.78	12.38	74.81	10.15	71.95	16.44
Emotion-Focused Coping	36.22	12.38	25.19	10.15	28.05	16.44

Note. Means with the same subscript within rows are significantly different at $p < 0.01$ based on Games–Howell post-hoc pairwise comparisons.
*$p < 0.01$.

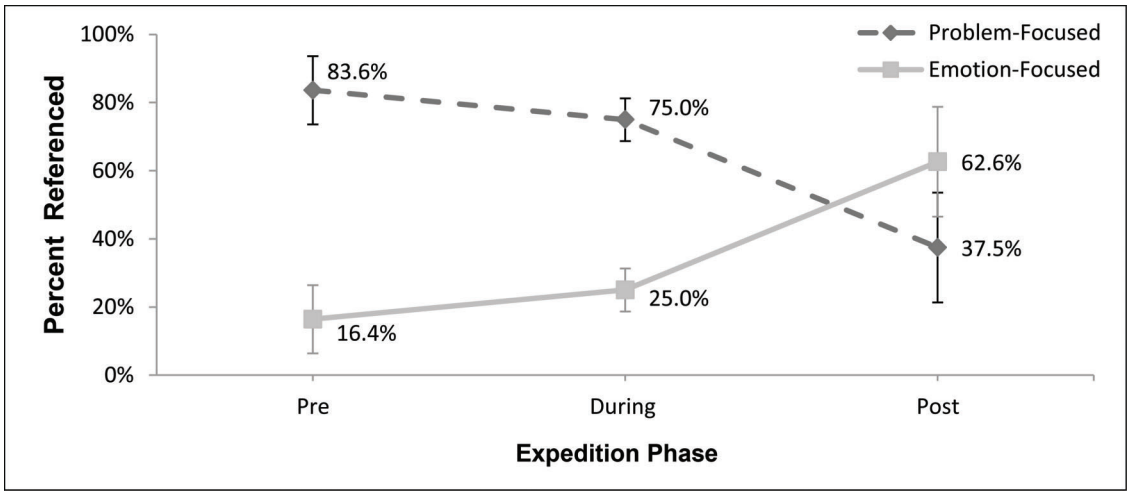

Figure 1. Proportion of references to emotion-focused versus problem-focused coping strategies across expedition phases. Error bars represent the standard error of the mean.

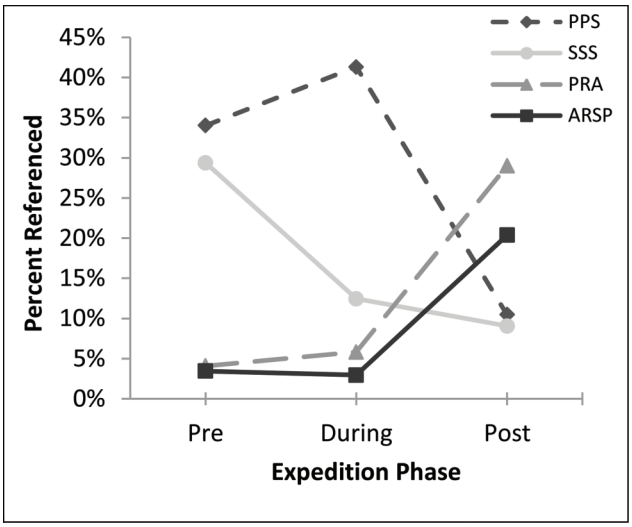

Figure 2. Coping strategies with significant or marginally significant differences in reference percentage across expedition phases (pre-, during-, and post-expedition). PPS, Planful Problem-Solving; SSS, Seeking Social Support; PRA, Positive Reappraisal, ARSP, Accepting Responsibility.

or during-expedition phases ($p = 0.01$ for both). Similarly, mentions of Accepting Responsibility also plateaued post-expedition, differing significantly from both pre-expedition and during-expedition levels ($p = 0.02$ and $p = 0.01$, respectively).

Differences at Specific Expedition Phases

Data for the comparison of pre-expedition coping strategies were available for 26 out of the 30 subject narratives. A nominally significant effect of cave exploration type on pre-expedition references to EOE was detected ($F(2, 7) = 4.24$, $p = 0.06$). Specifically, there was a trend toward a higher EOE reference percentage for terrestrial ($M = 16.43\%$, $SD = 21.62$) versus underwater cave explorers ($M = 1.39\%$, $SD = 3.92$; $p = 0.08$) based on post-hoc comparisons.

Data for the comparison of during-expedition coping strategies were available for all subject narratives. When comparing references to coping across categories of cave exploration, significant differences were identified for PPS ($F(2, 27) = 3.96$, $p = 0.03$), SSS ($F(2, 16) = 5.62$, $p = 0.01$), and EOE ($F(2, 14) = 6.95$, $p = 0.01$). Specifically, post-hoc analyses revealed that references to PPS were more frequent among underwater ($M = 51.82\%$, $SD = 24.12$) as compared to terrestrial ($M = 32.78\%$, $SD = 12.46$) cave explorers ($p = 0.04$). References to SSS were more frequent among terrestrial ($M = 16.93\%$, $SD = 9.81$) compared to terraqueous ($M = 6.85\%$, $SD = 3.99$) cave explorers ($p = 0.01$). Finally, references to EOE were less common among underwater cave explorers ($M = 6.96\%$, $SD = 7.75$) compared to both terrestrial ($M = 20.21\%$, $SD = 12.67$) and terraqueous ($M = 20.77\%$, $SD = 7.87$) cave explorers.

In addition to cave exploration type, nationality also significantly influenced mentions of during-expedition coping, namely PPS ($F(2, 26) = 3.89$, $p = 0.03$) and SSS ($F(2, 26) = 4.21$, $p = 0.03$). Specifically, it was found that PPS was more likely to be mentioned by American cave explorers ($M = 48.43\%$, $SD = 21.37$) than by French cave explorers ($M = 25.94\%$, $SD = 14.56$), and that SSS was more likely to be mentioned by French cave explorers ($M = 20.90\%$, $SD = 10.02$) than by British cave explorers ($M = 9.81\%$, $SD = 5.95$); $p = 0.03$ for both. No effects of leadership on during-expedition coping were detected. Also, there was no significant influence on post-expedition coping from either of the variables.

Discussion

This was the first investigation of coping in the context of cave exploration. Coping was assessed using a TCA approach previously developed and utilized by Suedfeld and colleagues (2009) to study coping strategies in the narratives of astronauts and cosmonauts. Overall, the results obtained were quite similar to those that Brcic (2013) found for mountaineers. This is not surprising when considering the many commonalities between cave exploration (especially the terrestrial and terraqueous forms) and mountaineering that were noted previously.

In line with our first hypothesis, references to problem-focused coping strategies were, overall, more common than references to emotion-focused coping strategies. As was also hypothesized, PPS, SSS, and EOE occupied the top three positions in the hierarchy of overall coping references made by cave explorers. Contrary to our predictions, however, the greatest problem-focused coping orientation emerged during the pre-expedition phase as opposed to the during-expedition phase. Nevertheless, the magnitude of difference between pre-expedition and during-expedition references to problem-focused coping strategies did not reach statistical significance. The predominance of problem-focused coping orientations in the pre-expedition phase is largely accounted for by a higher reference percentage of SSS, which significantly declined once expeditions were launched. Nevertheless, a prevailing orientation toward problem-focused coping was maintained throughout the during-expedition phase due to an accompanying increase in references to EOE and PPS.

By the post-expedition phase, overall differences in references to problem-focused versus emotion-focused coping strategies were no longer statistically significant. This was largely accounted for by an increase in references to Positive Reappraisal and Accepting Responsibility and an accompanying decrease in PPS. Although not hypothesized *a priori*, the significant post-expedition increases in the mention of Positive Reappraisal and Accepting Responsibility were not particularly surprising. A strong likelihood of obtaining this result became evident during

the research process. Moreover, Brcic (2013) previously reported a significant increase in post-mission references to Positive Reappraisal by other personnel pursuing activities in EUEs.

There is a growing recognition among psychologists (e.g., Cassel & Suedfeld, 2006; Palinkas, Gunderson, Holland, Miller, & Johnson, 2000; Ritsher, Kanas, Ihle, & Saylor, 2007; Suedfeld, Brcic, Johnson, & Gushin, 2012) that the highly stressful experiences and circumstances often encountered in EUEs can promote positive psychological growth, a phenomenon known as salutogenesis (Antonovsky, 1979). The ability to derive salutogenic effects from the stressful encounters typical of EUEs is likely to be associated with, or even contingent on, the employment of coping strategies that allow the stressor to be either successfully resolved or endured. Many examples of coping from our study suggest that Positive Reappraisal could be part of a mechanism by which stressful encounters (or their associated memories) catalyze salutogenic effects. The following passages reflect this theme in our data:

> *It was dark, and lonely, and immense…. I floated by the stalactites, tense, and shivering with more than cold. It wasn't a pleasant experience, the first time, and alone. Hanging in the freshwater, seeing and feeling the rays of the sun as it lanced through the green shallows, allowed adrenalin to submerge the fear, allowed me to stretch in delight at the experience, turning my body in a twisting somersault of emotion. I was alive, I had experienced a new and delicious sensation that had stimulated me in all my senses. I felt as though I had pressed beyond life and returned, gone out of the world and come back. Surely nothing else could intimidate me now.* (Palmer, 1989, p. 48)
>
> *Our journey back was, as you can well imagine, a toilsome business and the fatigue of the previous long struggle made some of it extremely trying, but we were carrying away a fine harvest of unforgettable scenes and our spirits found unfailing sustenance in the prospect of soon returning to resume this enthralling voyage of discovery.* (Casteret, 1947, p. 25)

Specifically, it seems that Positive Reappraisal facilitates salutogenesis by enabling cave explorers to derive positive meaning from stressful encounters. This suggested link between positive reappraisal and salutogenesis is consistent with Antonovsky's (1979) conceptualization of the phenomenon, particularly his emphasis on meaning as being central to the salutogenic process. It is worth noting that other coping strategies (including those not examined in this study) that infuse meaning into a stressful experience—what Folkman and Moskowitz (2000) further delineate as "meaning-focused" coping strategies—may similarly promote positive psychological growth. Future research will aim to evaluate this hypothesis and assess the relationship between meaning-focused coping and salutogenesis.

Limitations and Future Directions

There are several limitations to the current study that warrant recognition. The difficulty associated with locating and acquiring publicly available, first-person narrative materials of cave explorers resulted in considerable sample heterogeneity. As a result, there was a marked unequal distribution of subjects among the comparison groups (i.e., independent variables). This limited us from implementing mixed-model analyses that could simultaneously examine between-subjects and within-subjects effects, and thereby better control for potentially confounding factors. Variation in the sources of narrative materials also cannot be excluded as potentially biasing our results. Nevertheless, it is not obvious that utilizing only one or two sources of narrative material would not have also potentially introduced bias into the data. For example, by including audio transcripts and interviews in our dataset we did not limit our analysis to narratives generated by cave explorers who also happen to be writers. Another limitation of the present study that should be noted is that it does not provide any information regarding the success of these coping strategies. This remains a task for future studies.

There are also limitations that more generally reflect the use of TCA as a technique for qualitative data analysis. In many cases, the narrative materials used for TCA may not be written until months or possibly years after the events described had occurred. This was certainly true for many of the data sources used in this study. Thus, the reliability of the narratives cannot be validated, and are susceptible to potential bias introduced by the effects of memory error and distortion. However, it is noteworthy that a considerable portion of the narratives used for this study represent personal accounts that were recorded at the time of (or soon after) the expeditions they describe. A final caveat to be acknowledged is the potential that impression management effects had distorted or limited the content of the narratives, thereby causing some coping strategies to be over- or underrepresented, or perhaps not mentioned at all.

Although additional research will be required to validate and expand upon the results presented, these initial findings may help to inform practical applications in regards to success and safety of caving expeditions. This is a small, first step in understanding how cavers cope with a variety of technological, physical, and psychological stressors.

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